

CLAIMS

1. An imaging optical instrument for acquiring images of a sample area, comprising:
 - a spatial detector including a plurality of aligned detector elements,
 - a variable filter having filter characteristics that vary in at least one direction,wherein there is an optical path from the variable filter to the spatial detector, and
 - an actuator operatively connected between the variable filter and the spatial detector and operative to move the variable filter relative to the spatial detector along the direction in which the filter characteristics vary.
2. The apparatus of claim 1 wherein the variable filter is a variable band-pass filter.
3. The apparatus of claim 1 wherein the variable filter is a continuously variable filter.
4. The apparatus of claim 1 further including an infrared source and wherein the spatial detector is an infrared detector.
5. The apparatus of claim 1 further including a near infrared source and wherein the spatial detector is a near infrared detector.
6. The apparatus of claim 1 further including an ultraviolet source and wherein the spatial detector is an ultraviolet detector.
7. The apparatus of claim 1 further including a visible light source and wherein the spatial detector is a visible light detector.

8. The apparatus of claim 1 further including a narrow-band source and wherein the spatial detector and the variable filter are operative on wavelengths outside of the bandwidth of the source.

9. The apparatus of claim 1 further including logic responsive to the spatial detector to combine a series of images from the spatial detector to obtain spectral images.

10. The apparatus of claim 1 further including logic responsive to the spatial detector to combine data from a series of image pixels from images acquired by the spatial detector to obtain individual pixel spectra.

11. The apparatus of claim 1 further including the step of shifting acquired data on a line-by-line basis as it is being acquired.

12. The apparatus of claim 1 further including a first stage optic between the sample and the detector.

13. The apparatus of claim 12 wherein the first stage optic is an image formation optic.

14. The apparatus of claim 12 wherein the first stage optic includes a magnifying optic.

15. The apparatus of claim 12 wherein the first stage optic includes portions of an endoscopic imaging probe.

16. The apparatus of claim 1 further including logic responsive to the detector to selectively display spectral information that relates to at least one predetermined substance in the sample.

17. The apparatus of claim 1 further including multivariate spectral analysis logic responsive to data acquired by the detector.

18. The apparatus of claim 1 wherein the spatial detector is a two-dimensional array detector.

19. The apparatus of claim 1 wherein the spatial detector is an integrated semiconductor array detector.

20. The apparatus of claim 1 wherein the variable filter is between the sample area and the spatial detector.

21. The apparatus of claim 1 further including a source and wherein the variable filter is between the source and the sample area.

22. An optical spectroscopic method, comprising:
filtering a plurality of radiation beam portions for different positions in a sample area with a filter having different filter characteristics and being located at a first position,
detecting the plurality of radiation beam portions with different parts of a spatial detector after filtering the radiation beam portions in the step of filtering,
moving the filter to a second position relative to a detector used in the step of detecting,
again filtering the plurality of radiation beam portions with the filter at the second position,
again detecting the plurality of radiation beam portions with different parts of a spatial detector after filtering the radiation beam portions in the step of again filtering,
and
deriving spectral information from data acquired in the steps of detecting and again detecting.

23. The method of claim 22 wherein the step of deriving takes place after all of the steps of moving.

24. The method of claim 22 further including a step of focusing the radiation before the step of filtering.

25. The method of claim 22 wherein the steps of detecting acquire data representing a series of variably-filtered, two-dimensional images, and further including a step of combining the variably filtered images to obtain spectral images.

26. The method of claim 25 wherein the step of combining results in one or more Raman images.

27. The method of claim 25 wherein the step of combining results in one or more fluorescence images.

28. The method of claim 25 wherein the step of combining results in one or more infrared images.

29. The method of claim 25 wherein the step of combining results in one or more near-infrared images.

30. The method of claim 25 wherein the step of combining results in one or more visible images.

31. The method of claim 22 further including a step of providing a number of discrete sub-areas in the sample area.

32. The method of claim 31 wherein the step of providing sub-areas defines the sub-areas with an array of discrete reaction vessels.

33. The method of claim 31 wherein the step of providing sub-areas provides an array of different samples on a chip.

34. The method of claim 22 further including the step of magnifying the image before the step of detecting.

35. The method of claim 22 further including a step of performing a multivariate spectral analysis on results of the steps of detecting.

36. The method of claim 22 further including a step of selectively displaying spectral information that relates to at least one predetermined substance in the sample.

37. The method of claim 22 further including a step of providing a reference substance in the sample area.

38. The method of claim 22 wherein the steps of detecting are two-dimensional

39. A two-dimensional imaging optical instrument for acquiring images of a two-dimensional sample area irradiated by a source, comprising:

a two-dimensional spatial detector having detector elements aligned along a first axis and a second axis,

a two-dimensional variable filter having filter characteristics that vary in at least one dimension, wherein there is an optical path from the variable filter to the spatial detector, and

an actuator operatively connected to at least one of the source, the variable filter, the sample and the spatial detector, and operative to move at least the one of these elements with respect to at least another of these elements, wherein the actuator is driven by the instrument to enable detection of a predetermined sample area by a predetermined spatial detector area at a predetermined time.

40. The apparatus of claim 39 wherein the instrument includes common logic operative to control the actuator and cause the detector to acquire an image.

41. The apparatus of claim 39 wherein the spatial detector, the filter, and the actuator are all included in a same transportable instrument.

42. The apparatus of claim 41 wherein the instrument weighs less than 150 kilograms.

43. The apparatus of claim 39 wherein the source is an infrared source and wherein the spatial detector is an infrared detector.

44. The apparatus of claim 39 wherein the source is a near infrared source and wherein the spatial detector is a near infrared detector.

45. The apparatus of claim 39 further wherein the source is an ultraviolet source and wherein the spatial detector is an ultraviolet detector.

46. The apparatus of claim 39 further wherein the source is a visible light source and wherein the spatial detector is a visible light detector.

47. The apparatus of claim 39 wherein the source is a narrow-band source and wherein the spatial detector and the variable filter are operative on wavelengths outside of the bandwidth of the source.

48. The apparatus of claim 39 further including logic responsive to the spatial detector to combine a series of images from the spatial detector to obtain spectral images.

49. The apparatus of claim 39 further including logic responsive to the spatial detector to combine data from a series of image pixels from images acquired by the spatial detector to obtain individual pixel spectra.

50. The apparatus of claim 39 further including the step of shifting acquired data on a line-by-line basis as it is being acquired.

51. The apparatus of claim 39 further including a first stage optic between the sample and the detector.

52. The apparatus of claim 51 wherein the first stage optic is an image formation optic.

53. The apparatus of claim 51 wherein the first stage optic includes a magnifying optic.

54. The apparatus of claim 51 wherein the first stage optic includes portions of an endoscopic imaging probe.

55. The apparatus of claim 39 further including logic responsive to the detector to selectively display spectral information that relates to at least one predetermined substance in the sample.

56. The apparatus of claim 39 further including multivariate spectral analysis logic responsive to data acquired by the detector.

57. The apparatus of claim 39 wherein the spatial detector is an integrated semiconductor array detector.

58. An optical spectroscopic method, comprising:
filtering a plurality of radiation beam portions for a first set of different positions in a sample area with different filter characteristics,
detecting the plurality of radiation beam portions with different parts of a spatial detector after filtering the radiation beam portions in the first step,

successively filtering further pluralities of radiation beam portions for further sets of different positions in the sample area with the same filter characteristics after the steps of filtering and detecting, wherein the further sets of positions are different from the first set and from each other, and

successively detecting the further pluralities of radiation beam portions with different parts of a spatial detector after filtering the further pluralities of radiation beam portions, and

deriving spectral information about predetermined positions in the sample from data acquired in the steps of detecting and successively detecting.

59. The method of claim 58 further including a step of moving a filter that performs the first and third steps between the first and third steps.

60. The method of claim 59 wherein the step of moving the filter moves the filter relative to the rest of the elements in an instrument that performs the method.

61. The method of claim 59 wherein the step of moving the filter moves at least another element of an instrument that performs the method with respect to the filter, and wherein the filter remains stationary relative to the rest of the elements in the instrument.

62. The method of claim 59 wherein the step of moving and the steps of acquiring are responsive to common control logic.

63. The method of claim 58 further including a step of focusing the radiation before the step of filtering.

64. The method of claim 58 wherein the steps of detecting acquire data representing a series of variably-filtered, two-dimensional images, and further including a step of combining the variably filtered images to obtain spectral images.

65. The method of claim 64 wherein the step of combining results in one or more Raman images.

66. The method of claim 65 wherein the step of combining results in one or more fluorescence images.

67. The method of claim 65 wherein the step of combining results in one or more infrared images.

68. The method of claim 65 wherein the step of combining results in one or more near-infrared images.

69. The method of claim 65 wherein the step of combining results in one or more visible images.

70. The method of claim 58 further including a step of providing a number of discrete sub-areas in the sample area.

71. The method of claim 70 wherein the step of providing sub-areas defines the sub-areas with an array of discrete reaction vessels.

72. The method of claim 70 wherein the step of providing sub-areas provides an array of different samples on a chip.

73. The method of claim 58 further including the step of magnifying the image before the step of detecting.

74. The method of claim 58 further including a step of performing a multivariate spectral analysis on results of the steps of detecting.

75. The method of claim 58 further including a step of selectively displaying spectral information that relates to at least one predetermined substance in the sample.

76. The method of claim 58 further including a step of providing a reference substance in the sample area.

77. An optical instrument, comprising:
a spatial detector including a plurality of aligned detector elements,
a first variable filter having filter characteristics that vary in at least a first direction,
a second variable filter having filter characteristics that vary in at least a second direction, and
a sample area positioned such that there is an optical path that passes through the first filter, that interacts with the sample, that passes through the second filter, and that reaches the detector.

78. The apparatus of claim 77 wherein the optical path begins at a source, then passes through the first filter, then passes through the sample, then passes through the second filter, and then reaches the detector.

79. The apparatus of claim 77 further including an actuator connected to at least one of the variable filters, the sample area, and the spatial detector.

80. The apparatus of claim 77 wherein the variable filters are variable band-pass filters.

81. The apparatus of claim 77 wherein the variable filters are continuously variable filters.

82. The apparatus of claim 77 further including an ultraviolet source and wherein the spatial detector is an ultraviolet detector.

83. The apparatus of claim 77 further including an ultraviolet source and wherein the spatial detector is a visible detector.

84. The apparatus of claim 77 wherein the spatial detector and the second variable filter are operative on wavelengths outside of the bandwidth of the source.

85. The apparatus of claim 77 wherein the optical axes of the first and second filters are at an angle with respect to each other.

86. The apparatus of claim 85 wherein the optical axes of the first and second filters are at a right angle with respect to each other.

87. The apparatus of claim 77 wherein the first and second directions are at an angle with respect to each other.

88. The apparatus of claim 87 wherein the first and second directions are at a right angle with respect to each other.

89. The apparatus of claim 77 further including logic responsive to the spatial detector to combine a series of images from the spatial detector to obtain spectral images.

90. The apparatus of claim 77 further including logic responsive to the spatial detector to combine data from a series of image pixels from images acquired by the spatial detector to obtain individual pixel spectra.

91. The apparatus of claim 77 further including the step of shifting acquired data on a line-by-line basis as it is being acquired.

92. The apparatus of claim 77 further including a first stage optic between the sample and the detector.

93. The apparatus of claim 92 wherein the first stage optic is an image formation optic.

94. The apparatus of claim 92 wherein the first stage optic includes a magnifying optic.

95. The apparatus of claim 77 further including logic responsive to the detector to selectively display spectral information that relates to at least one predetermined substance in the sample.

96. The apparatus of claim 77 further including multivariate spectral analysis logic responsive to data acquired by the detector.

97. The apparatus of claim 77 wherein the spatial detector is an integrated semiconductor array detector.

98. The apparatus of claim 77 wherein the first variable filter is between the source and the sample area and wherein the second variable filter is between the sample area and the source.

99. The apparatus of claim 77 wherein the sample area is positioned such that there is an optical path that passes through the first filter, that then interacts with the sample, that then passes through the second filter, and that then reaches the detector.

100. The apparatus of claim 77 further including logic operatively connected to the detector to convert signals from the detector into a fluorescence excitation-emission map.

101. The apparatus of claim 77 further including logic operatively connected to the detector to convert signals from the detector into a spectral map.

102. The apparatus of claim 77 further including logic operatively connected to the detector to convert signals from the detector into a spectral map in real time.

103. The apparatus of claim 77 wherein the spatial detector is a two-dimensional array detector.

104. An optical spectroscopic method, comprising:

a first step including filtering a plurality of radiation beam portions for a first set of different positions in a sample area with a first set of different filter characteristics,

a second step including filtering a plurality of radiation beam portions for the first set of different positions in the sample area with a second set of filter characteristics different from the first set of filter characteristics, and

a third step including detecting a plurality of radiation beam portions each resulting from the first and second steps, wherein the third step takes place after the first and second steps.

105. The apparatus of claim 104 wherein the first step of filtering and the second step of filtering operate with their optical axes at an angle with respect to each other.

106. The apparatus of claim 105 wherein the first step of filtering and the second step of filtering operate with their optical axes at a right angle with respect to each other.

107. The apparatus of claim 104 wherein the first step of filtering and the second step of filtering operate with a direction of change of filter characteristics of the first step of filtering and a direction of change of filter characteristics of the second step of filtering at an angle with respect to each other.

108. The apparatus of claim 107 wherein the first step of filtering and the second step of filtering operate with a direction of change of filter characteristics of the first step

of filtering and the direction of change of filter characteristics of the second step at a right angle with respect to each other.

109. The method of claim 104 further including a step of focusing the radiation before the step of filtering.

110. The method of claim 104 wherein the step of detecting acquires data representing a variably-filtered, two-dimensional image, and further including a step of combining the variably filtered image with other variably filtered images to obtain spectral images.

111. The method of claim 110 wherein the step of combining results in one or more fluorescence images.

112. The method of claim 104 further including a step of providing a number of discrete sub-areas in the sample area.

113. The method of claim 104 wherein the step of providing sub-areas defines the sub-areas with an array of discrete reaction vessels.

114. The method of claim 113 wherein the step of providing sub-areas provides an array of different samples on a chip.

115. The method of claim 104 further including the step of magnifying the image before the step of detecting.

116. The method of claim 104 further including a step of performing a multivariate spectral analysis on results of the step of detecting.

117. The method of claim 104 further including a step of selectively displaying spectral information that relates to at least one predetermined substance in the sample.

118. The method of claim 104 further including a step of providing a reference substance in the sample area.

119. The method of claim 104 further including a step of converting results of the step of detecting into a fluorescence excitation-emission map.

120. The method of claim 104 further including a step of converting results of the step of detecting into a spectral map.

121. The method of claim 104 further including a step of converting results of the step of detecting into a spectral map in real time.

122. The method of claim 104 further including a step of moving an optical element that performs one of the first, second, and a step of repeating the third step in concert with the step of moving.

123. The method of claim 104 further including a step of moving a filter that performs one of the first and second steps, and a step of repeating the third step in concert with the step of moving.